JAPANESE PATENT PUBLICATION (A)

(11)Publication number: 2001-156434
(43)Date of publication of application: 08.06.2001

(51)Int.Cl. H05K 3/34
B23K 1/00
B23K 3/06
H01L 21/60
H01L 23/12

(21)Application number: 11-340064
(22)Date of filing: 30.11.1999

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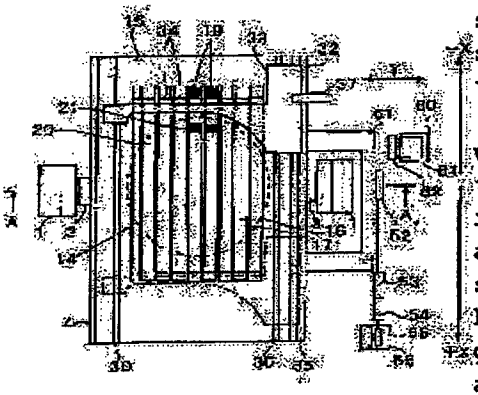
(54) SOLDER BALL MOUNTING METHOD AND DEVICE

(57) [Abstract]
[Problem] To provide a method and apparatus for mounting solder balls able to mount 20,000 to 30,000 solder balls on a workpiece by a single process and able to improve the work efficiency.
[Means for Solving] A mask 20 and a workpiece 14 are positioned on a tilt table 4, then the tilt table 4 is made to tilt by a predetermined angle about tilt pins 3 so that a squeegee 34 side becomes higher. Further, solder balls 19 of a number greater than the number of holes 21 are supplied to the holes 16 on the opposite side from the workpiece 14 sectioned off by squeegees 34, then the squeegees 34 are made to move by a predetermined speed (speed slower than speed by which solder balls 19 fall by gravity) to the lower side. After the squeegees 34 move to the outside of the area where the holes 21 are arranged, the tilt table 4 is tilted in a direction opposite to the previous one, solder balls 19 not engaged with the holes 21 are removed, then the tilt table 4 is returned to the horizontal and finally the squeegees 34 are returned to their original positions.



[CLAIMS]
[Claim 1]A method of mounting solder balls which aligns a workpiece coated with flux at predetermined positions of its surface and a mask formed with holes of a size enabling the solder balls to pass through at positions corresponding to the coating positions of said flux so that the mask is at the top and mounting said solder balls on said flux through said holes from the surface side of said mask, characterized by positioning said mask and said workpiece relative to each other, then inclining the two by a predetermined angle, supplying a number of said solder balls in an amount greater than the number of said holes to the surface of said mask at the higher end outside the area where said holes are arranged, making said solder balls move along said surface while restricting the speed of dropping to a predetermined speed, making at least part of said solder balls move to the lower end outside of said area, inclining the two in a direction opposite to the previous one, and removing said solder balls not engaged with said holes from said mask.
[Claim 2]An apparatus for mounting solder balls which aligns a workpiece coated with flux at predetermined positions of its surface and a mask formed with holes of a size enabling the solder balls to pass through at positions corresponding to the coating positions of said flux so that the mask is at the top and mounting said solder balls on said flux through said holes from the surface side of said mask, characterized by being provided with a tilt table forming two facing sides in parallel at a surface side of said mask, forming a wall surrounding the area in which said holes are arranged, and able to tilt in two directions with respect to a horizontal plane, squeegees with two ends engaged with said two sides, with bottom ends separated by a predetermined distance from the surface of said mask, and able to move through said area in the direction of the two sides, and a means for moving said squeegees and by having said workpiece and said mask be supported at said tilt table with the directions of said two sides inclined.
[DETAILED DESCRIPTION OF THE INVENTION]
[0001]
[Technical Field of the Invention]The present invention relates to a method and apparatus for mounting solder balls which mounts solder balls on flux coated on connection pads formed on the surface of a printed circuit board, semiconductor wafer, etc.
[0002]
[Prior Art]In the ball grid array method (hereinafter referred to as the "BGA method"), holes smaller than the solder balls are formed in the mask at positions corresponding to the pads placed on the workpiece surface. Further, solder balls are held by suction at these holes, then the bottom ends of the solder balls are dipped slightly in a flux tank to coat the

surfaces of the solder balls with flux. After this, the solder balls are pushed against the pads to mount the solder balls on the pads through the coated flux. As a result, a single process enables a large number of solder balls to be mounted on pads.

[0003]

[Problem to be Solved by the Invention]However, with the above BGA method, since the solder balls vary in outside diameter, if coating the flux matching with the small diameter solder balls, flux will sometimes stick to the mask and even if stopping the suction, the solder balls will sometimes not separate from the mask. Therefore, it was necessary to reduce the allowable error in outside diameter of the balls and constantly manage the height and flatness of the flux surface. Accordingly, the work efficiency could not be improved. Further, the number of solder balls able to be mounted in a single process was just up to around 1000.

[0004]An object of the present invention is to solve the above problem and provide a method and apparatus for mounting solder balls able to mount 20,000 to 30,000 solder balls on a workpiece in a single process and therefore able to improve the work efficiency.

[0005]

[Means for Solving the Problems]To achieve the above object, the aspect of the invention of claim 1 provides a method of mounting solder balls which aligns a workpiece coated with flux at predetermined positions of its surface and a mask formed with holes of a size enabling the solder balls to pass through at positions corresponding to the coating positions of said flux so that the mask is at the top and mounting said solder balls on said flux through said holes from the surface side of said mask, characterized by positioning said mask and said workpiece relative to each other, then inclining the two by a predetermined angle, supplying a number of said solder balls in an amount greater than the number of said holes to the surface of said mask at the higher end outside the area where said holes are arranged, making said solder balls move along said surface while restricting the speed of dropping to a predetermined speed, making at least part of said solder balls move to the lower end outside of said area, inclining the two in a direction opposite to the previous one, and removing said solder balls not engaged with said holes from said mask.

[0006]Further, the aspect of the invention of claim 2 provides an apparatus for mounting solder balls which aligns a workpiece coated with flux at predetermined positions of its surface and a mask formed with holes of a size enabling the solder balls to pass through at positions corresponding to the coating positions of said flux so that the mask is at the top and mounting said solder balls on said flux through said holes from the surface side of said mask, characterized by being

provided with a tilt table forming a set of two facing sides in parallel at a surface side of said mask, forming a wall surrounding the area in which said holes are arranged, and able to tilt in two directions with respect to a horizontal plane, squeegees with two ends engaged with said two sides, with bottom ends separated by a predetermined distance from the surface of said mask, and able to move through said area in the direction of the two sides, and a means for moving said squeegees and by having said workpiece and said mask be supported at said tilt table with the directions of said two sides inclined.

[0007]

[Embodiments of the Invention]Below, the present invention will be explained based on the embodiment shown in the figures. First, the overall configuration will be explained.

[0008]FIG. 1 is a plan view of an apparatus for mounting solder balls according to the present invention, while FIG. 2 is a cross-sectional view along A-A of FIG. 1. A pair of tilt pins 3 are fastened to the two sides of the tilt table 4. The tilt pins 3 are rotably engaged with a bearing 2 held by a pair of brackets 1. The brackets 1 are fastened to a base 100. As shown in FIG. 2, the tilt table 4 has a table 11 fastened to it. The table 11 holds a workpiece 14. Further, a mask jig 15 is positioned at the tilt table 4 through two pairs of guide pins 18.

[0009]At the bottom surface of the mask jig 15 is fastened a mask 20 formed with a large number of holes 21. Further, at the center hole part of the mask jig 15, a plurality of ribs 17 are arranged in the X-direction (vertical direction in FIG. 1), whereby a plurality of rectangular holes 16 are formed. At the top side of the mask jig 15, a pair of guide rails 30 is fastened. A holder 32 is fastened to a linear bearing 31 engaged with the guide rails 30 and can move in the X-direction. The side surface of the holder 32 is formed with a groove 33. The holder 32 supports the same number of squeegees 34 as the holes 16 of widths engaging with the holes 16. The holes 16 at the opposite side from the workpiece 14 sectioned off by the squeegees 34 store solder balls 19. A guide rail 35 is fastened to the tilt table 4 so as to become parallel to the guide rails 30. A driving hook 37 engaged with the groove 33 is fastened to the linear bearing 36 engaged with the guide rail 35.

[0010]The side surface of the tilt table 4 has a bracket 51 fastened to it. A shaft 52 fastened to the bracket 51 has a piston rod of a tilt cylinder 53 rotably engaged with it. A cylinder of the tilt cylinder 53 is fastened to the cylinder of the tilt cylinder 54, while a piston rod of the tilt cylinder 54 is rotably fastened to a shaft 56 fastened to a stand 55. The stand 55 is fastened to a base 100. Further, when one of the piston rods of the tilt cylinders 53, 54 extends and the other retracts, the axial center of the shaft

52 and the axial center of the tilt pin 3 are aligned on the vertical.

[0011]A bracket 60 fastened to the base 100 has a stopper cylinder 61 fastened to it. The stopper cylinder 61 moves a stopper 62 fastened to its front end in a Y-direction perpendicular to the X-direction.

[0012]Next, this will be explained in further detail using FIGS. 3 and 4.

[0013]FIG. 3 is an enlarged view of a part B in FIG. 2, while FIG. 4 is an enlarged showing the relationship between the workpiece 14 and mask 20 in FIG. 3. The top surface of the table 11 is formed with a plurality of vacuum suction pockets 12. These are connected through a passageway 13 to a vacuum source. The surface of the workpiece 14 is coated with a flux F in advance. The diameter of the holes 21 provided in the mask 20 is slightly smaller than the solder balls 19. Ribs 22 thicker than the coating thickness of the flux F are arranged at positions corresponding to the ribs 17 on the bottom of the mask 20 (surface at workpiece 14 side).

[0014]The distance between the bottom ends of the squeegees 34 and the surface of the mask 20 (surface on opposite side to the workpiece 14) is formed sufficiently smaller than the radius of the solder balls 19 and of a size not contacting the surface of the mask 20. Further, the distance between the squeegees 34 and the ribs 17 is formed sufficiently smaller than the radius of the solder balls 19.

[0015]Next, the relationship between the mask jig 15 and tilt table 4 will be explained in further detail. FIG. 5 is a cross-sectional view along C-C of FIG. 2. The tilt table 4 has two pairs of arm pins 23 fastened to it. The arm pins 23 rotably support link arms 24. The link arms 24 have arm rods 25 fastened to them. The arm rods 25 rotably support a parallel link 26. Further, the tilt table 4, link arms 24, and parallel links 26 form a parallel square link.

[0016]One end of the tilt table 4 has a bracket 27 fastened to it. The bracket 27 has a motor 28 fastened to it. The motor 28 moves the rod 29 abutting against one link arm 24 in the axial direction of the motor 28. Further, when the rod 29 is most retracted, that is, when the parallel link 26 is at the bottom end of the movement area, a slight clearance is formed between the other ends of the guide pins 18 fastened to the mask jig 15 and the parallel link 26. Further, when the rod 29 is most extended, the mask jig 15 rises by exactly h through the guide pins 18.

[0017]Next, the means for tilting the tilt table 4 will be explained.

[0018]FIG. 6 is a side view of FIG. 1, while FIG. 7 is a view along the arrow D of FIG. 6. As shown in FIG. 6, when the tilt table 4 is horizontal, the tilt cylinder 53 is in a state with the piston rod extended, the tilt cylinder 54 is in a state with the piston rod retracted. Further, the stopper 62 is at

the projecting end shown by the two-dot chain line in FIG. 7 and abuts against the bracket 5 at its top end. In this state, if the piston rod of the tilt cylinder 54 is extended, as shown by the two-dot chain line in FIG. 6, the tilt table 4 tilts to the top right by the angle θ. On the other hand, if moving the stopper 62 to the recessed end and retracting the piston rod of the tilt cylinder 53, the tilt table 4 tilts to the bottom right by the angle α.

[0019]Next, the operation of the present invention will be explained. Note that the holder 32 is at the position shown in FIG. 1 (hereinafter referred to as the "standby position"), while the driving hook 37 is engaged with the groove 33. FIGS. 8 to 11 are views showing the steps in the process of mounting solder balls. In the state with the tilt table 4 horizontal, the motor 28 is operated to raise the mask jig 15 by h (distance enabling workpiece 14 to be easily loaded and unloaded manually or by an automatic conveying means, 6 to 10 mm or so) and the workpiece 14 is positioned on the table 11. The top surface of the table 11 is provided with positioning means for positioning it in the rotational direction utilizing features such as grooves restraining the outer shape of the workpiece 14 and positioning it in the horizontal direction or notches formed in the workpiece 14. All of the flux F is positioned so as to face the holes 21. In this state, the vacuum source is used to fasten the workpiece 14 to the table 11, the motor 28 is operated to position the rod 29 at the most retracted position. This being the case, the weight of the mask jig 15 and the other members carried on the mask jig 15 causes the mask 15 to descend and the bottom ends of the ribs 22 to strike the surface of the workpiece 14.

[0020]Next, the holes 16 on the opposite side from the workpiece 15 sectioned off by the squeegees 34 are supplied with two to three times the number of solder balls 19 as the number of the holes 21. Further, when tilting the tilt table 4 by an angle θ, as shown in FIG. 8, the table 11 and the mask jig 15 are also simultaneously tilted. At this time, the solder balls 19 are supported by the squeegees 34, so will not drop down due to gravity. Note that the angle θ is set so that the solder balls will roll down over the mask by gravity and easily drop into the holes 21 (for example, 20 degrees to 40 degrees).

[0021]In this state, a not shown belt is used to make the driving hook 37 move in the +X direction by a predetermined speed. The speed for moving the squeegees 34 is set to a speed enabling the solder balls 19 rolling down over the mask 20 due to gravity to reliably drop into the holes 21 of the mask 20. That is, for example, when the angle θ is 25 degrees and the diameter of the solder balls 19 is 0.3 mm, the speed of movement of the squeegees 34 is set to 5 to 30 mm/seconds. This being so, as shown in FIG. 9, the solder balls 19 pile up near the squeegees 34, but spread out inside the hole 16 at

the back end and roll down over the surface of the mask 20 in a single layer, whereby the solder balls 19 reliably drop into the holes 21, are held by the tackiness of the flux F, and are mounted on the workpiece 14. When one solder ball 19 enters a hole 21, the following solder balls 19 ride over the solder ball 19 in the hole 21 and roll on.

[0022]As shown in FIG. 10, after the squeegees 34 pass the area of the holes 21 (hereinafter referred to as the "movement end position"), the movement of the squeegees 34 is stopped. Further, after the stopper 62 is moved to the recessed end, as shown in FIG. 11, the tilt table 4 is inclined by the angle α. This being so, the solder balls 19 not entering the holes 21 move to the standby position due to gravity. Note that the angle α is set to a size whereby the solder balls 19 in the holes 21 will not be made to rotate by the moving solder balls 19 (for example, 25 degrees to 45 degrees). Further, the solder balls 19 moved to the standby position side are recovered by a not shown means.

[0023]Next, the tilt table 4 is returned to the horizontal, the stopper 62 is moved to the projecting end, and the stopper 62 is used to fasten the tilt table 4. After this, the squeegees 34 are returned to the standby position. At this time, the squeegees 34 return the excess solder balls 19 remaining on the surface of the mask 20 to the standby position and push the solder balls 19 in the holes 21 into the flux F. As a result, the solder balls 19 are reliably held by the flux F.

[0024]After the squeegees 34 are returned to the standby position, the mask jig 15 is raised and the workpiece 14 is taken out.

[0025]Note that the reason why the tilt table 4 is made to tilt by an angle α in the state with the squeegees 34 stopped at the movement end position and move the excess solder balls 19 to the standby position side is as follows. That is, if returning the squeegees 34 to the standby position in the state with the solder balls 19 remaining on the mask 20, as shown in FIG. 12, the excess solder balls 19 will rotate supported by the squeegees 34 and make the solder balls 19 in the holes 21 rotate. If the solder balls 19 in the holes 21 rotate, the flux F will stick to the side surfaces of the holes 21 (f in the figure) and, when raising the mask jig 15, the solder balls 19 will sometimes stick to the holes 21 and not separate from the workpiece 14. On the other hand, adopting the above procedure enables this trouble to be prevented.

[0026]In this embodiment, the motor 28 makes the link arm 24 operate, so when making the mask 20 move away from the workpiece 14, it is possible to slow the speed of movement of the mask 20 and enable the mask 20 to be reliably separated without making the solder balls 19 move even if the solder balls 19 contact the inner circumferences of the holes 21.

Further, by increasing the speed of the motor 28 after the mask 20 separates from the solder balls 19, the time for movement of the mask jig 15 can be shortened. Further, when making the mask 20 contact the workpiece 14, the workpiece 14 will not be given an unnecessary impact.

[0027]Note that when making the tilt table 4 tilt or when returning it to the horizontal state, it is possible to control the amount of supply of the pressurized fluid supplied to the tilt cylinders 53, 54 so as to smoothly accelerate or decelerate them at the time of starting the tilt and the time of stopping it.

[0028]Further, when making the mask 20 move away from the workpiece 14, the mask jig 15 may be given a fine vibration so as to make the mask 20 and solder balls 19 reliably separate.

[0029]

[Effects of the Invention]As explained above, according to the present invention, there is provided a method of mounting solder balls which aligns a workpiece coated with flux at predetermined positions of its surface and a mask formed with holes of a size enabling the solder balls to pass through at positions corresponding to the coating positions of said flux so that the mask is at the top and mounting said solder balls on said flux through said holes from the surface side of said mask, characterized by positioning said mask and said workpiece relative to each other, then inclining the two by a predetermined angle, supplying a number of said solder balls in an amount greater than the number of said holes to the surface of said mask at the higher end outside the area where said holes are arranged, making said solder balls move along said surface while restricting the speed of dropping to a predetermined speed, making at least part of said solder balls move to the lower end outside of said area, inclining the two in a direction opposite to the previous one, and removing said solder balls not engaged with said holes from said mask, so it is possible to mount 20,000 to 30,000 solder balls on a workpiece by a single process and for example it is possible to reliably mount solder balls on the entire area of even a workpiece comprised of an 8 inch wafer by a single process.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[FIG. 1]A plan view of a solder ball mounting apparatus according to the present invention.

[FIG. 2]A cross-sectional view along the line A-A of FIG. 1.

[FIG. 3]An enlarged view of the part B in FIG. 2.

[FIG. 4]An enlarged view showing the relationship between the workpiece 14 and mask 20 in FIG. 3.

[FIG. 5]A cross-sectional view along the line C-C of FIG. 2.

[FIG. 6]A side view of FIG. 1.

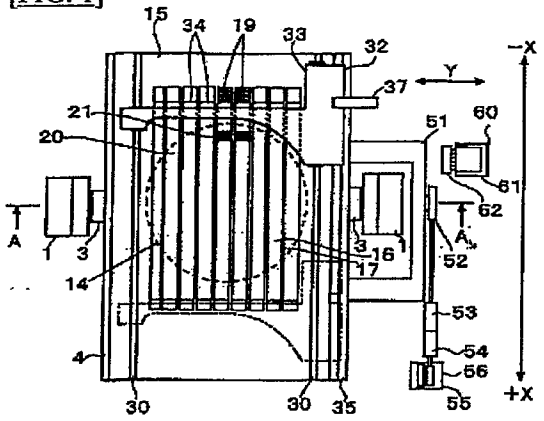
[FIG. 7]A view along the arrow D of FIG. 6.

[FIG. 8]A view showing a process of mounting solder balls in the present invention.

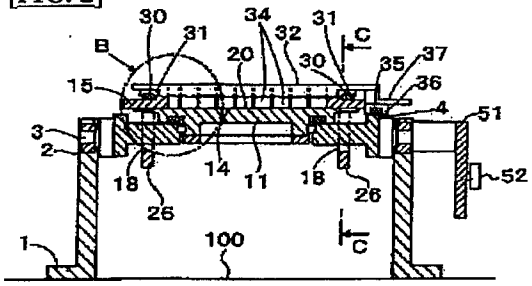
[FIG. 9]A view showing a process of mounting solder balls in

the present invention.
[FIG. 10]A view showing a process of mounting solder balls in the present invention.
[FIG. 11]A view showing a process of mounting solder balls in the present invention.
[FIG. 12]A view for explaining the features of the present invention.
[Description of Notation]
3 tilt pin
4 tilt table
14 workpiece
16 hole
19 solder balls
20 mask
21 hole
34 squeegee

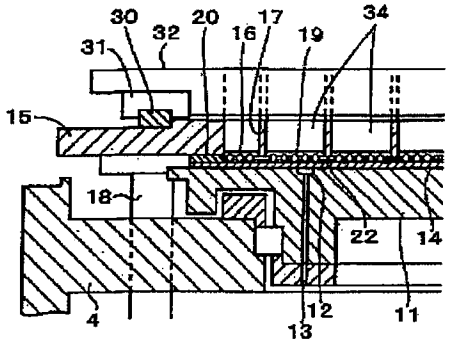
[FIG. 1]



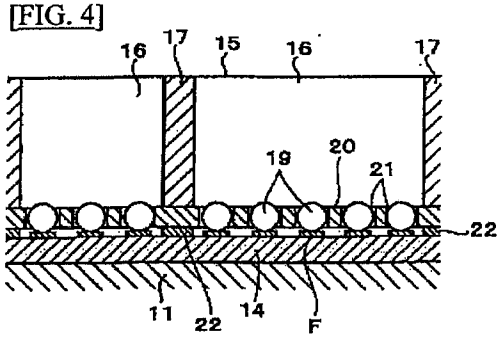
[FIG. 2]



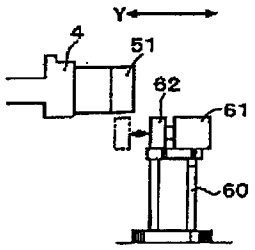
[FIG. 3]



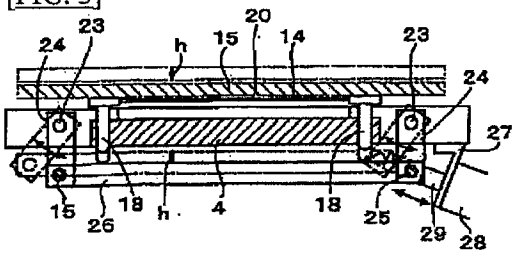
[FIG. 4]



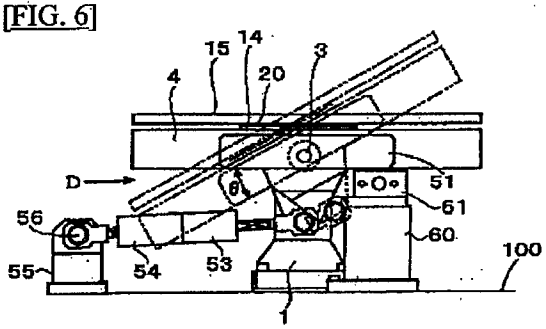
[FIG. 7]



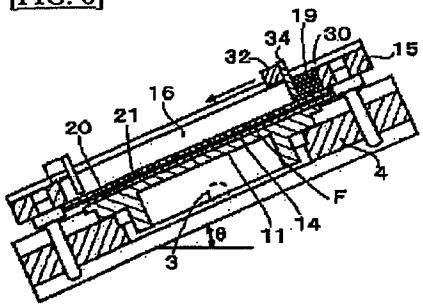
[FIG. 5]



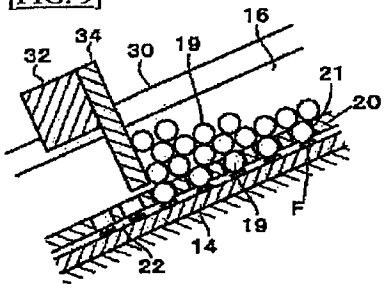
[FIG. 6]



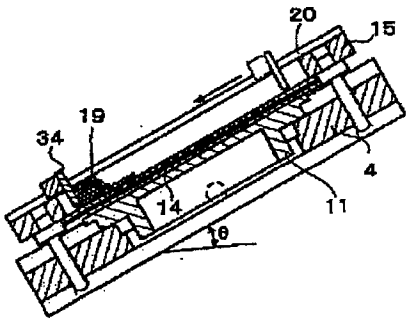
[FIG. 8]



[FIG. 9]



[FIG. 10]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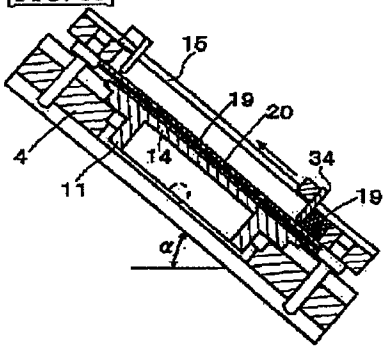
[FIG. 11]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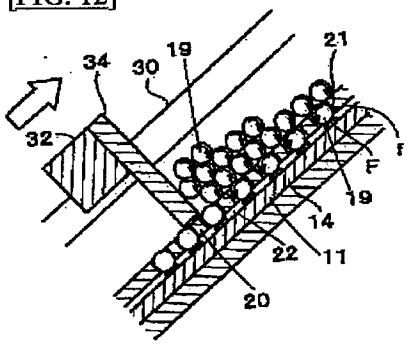
[FIG. 12]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